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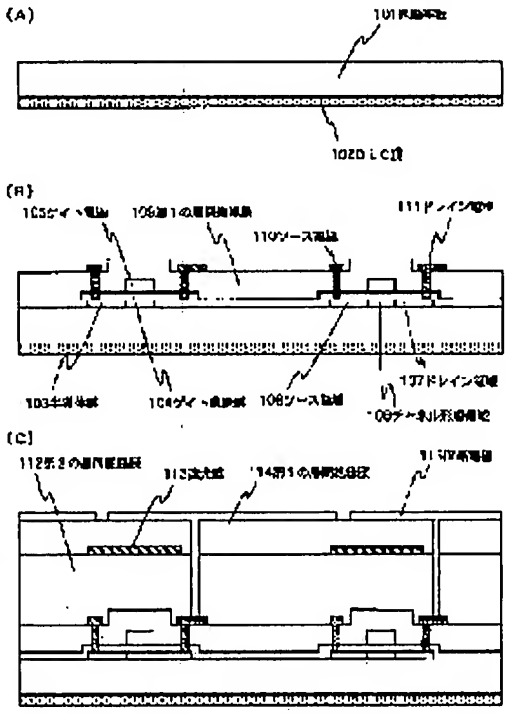
(54) SEMICONDUCTOR DEVICE AND ITS MANUFACTURE

(57)Abstract:

PROBLEM TO BE SOLVED: To prevent an electrostatic break down and increase reliability by a method wherein thin film transistors are formed on an insulation substrate, and a diamond-like carbon film is formed on a face counter to a face on which the thin film transistors of the insulation film are formed.

SOLUTION: A diamond-like carbon(DLC) film 102 is formed on a surface of an insulation substrate 101, and a buffer layer is provided between the insulation substrate 101 and the DLC film 102. A semiconductor film 103 is formed on the insulation substrate 101. A gate insulation film 104 and a gate electrode 105 are formed on the semiconductor film 103. Impuritie are injected into the semiconductor film to form a source region 106 and a drain region 107. The gate insulation film 104 and the gate electrode 105 are covered to form a first interlayer insulation film 109. A contact hole is formed in the gate insulation film 104 and the first interlayer insulation film 109, and a source electrode 107 and a drain electrode 108 are formed to form thin film transistors(TFT). Thus, it is possible to prevent an electrostatic breakage of TFT and realize an electronic apparatus of high reliability.



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* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] The invention in this application relates to the configuration and the production approach of a semiconductor device of having the thin film transistor (TFT) formed on the substrate.
[0002]
[Description of the Prior Art] The liquid crystal display (LCD) attracts attention according to the descriptions, such as a thin shape, a light weight, and a low power, as an image display device which replaces CRT.
[0003] One of the classes of liquid crystal display has a TFT-liquid-crystal display (TFT-LCD). This is the liquid crystal display of the active-matrix drive method which used the thin film transistor (TFT) as a switching element of a pixel.
[0004] Much TFT(s) arranged at each pixel are formed on an insulating substrate, and this active matrix liquid crystal display constitutes the active-matrix circuit. Furthermore, recently, the drive circuit for driving a active-matrix circuit and the display formed on the insulating substrate are proposed. This drive circuit also consists of components, such as much TFT(s).
[0005]
[Problem(s) to be Solved by the Invention] Thus, since many TFT(s) are formed on the insulating substrate, an active matrix liquid crystal display is weak to static electricity. It generates, when a liquid crystal display is worn with people and an object, and static electricity is charged in an insulating substrate etc.
[0006] Especially TFT is easy to be destroyed by this electrified static electricity. As for this, since the gate dielectric film is as thin as 50-200nm, for the high voltage, starting is from a lifting or a cone about dielectric breakdown by static electricity at gate dielectric film. Moreover, a high current will flow to the barrier layer of TFT with static electricity, and that will deteriorate. Furthermore, when severe, it may exfoliate.
[0007] And when TFT breaks down, the pixel of a liquid crystal display remains being an ON state or an OFF state, and a defect will arise in the display of a liquid crystal display.
[0008] Such an electrostatic discharge may happen not only under use of a liquid crystal display but during production of a liquid crystal display. In production, when it touches with people and equipment, it is easy to generate static electricity.
[0009] The invention in this application prevents the above electrostatic discharges, and aims at offering a reliable semiconductor device.
[0010]
[Means for Solving the Problem] The configuration of invention indicated on these specifications is characterized by having the diamond-like carbon film formed in the field opposite to the field in which the thin film transistor formed on the insulating substrate and said thin film transistor of said insulating substrate are formed.

[0011] Here, it is also called diamond-like carbon (Diamond-like Carbon, omitting DLC), hard carbon, and i-carbon, and diamond-like carbon is sp3. It is amorphous carbon which made association the subject. However, the microcrystal of a diamond may be contained depending on production conditions.
[0012] Moreover, the configuration of other invention is characterized by having the diamond-like carbon film formed on the insulating substrate, the substrate film formed on said diamond-like carbon film, and the thin film transistor formed on said substrate film.
[0013] Furthermore, the configuration of other invention is characterized by having the thin film transistor formed on the insulating substrate, the interlayer insulation film formed on said thin film transistor, and the diamond-like carbon film formed on said interlayer insulation film.
[0014] Moreover, it is the production approach of the semiconductor device characterized by forming the diamond-like carbon film in a field opposite to the field in which said insulating substrate forms said thin film transistor in the production approach of a semiconductor device that the configuration of the production approach of this invention forms a thin film transistor on an insulating substrate.
[0015] The configuration of other invention is the production approach of the semiconductor device characterized by having the process which forms a diamond-like carbon film on an insulating substrate, the process which forms the substrate film on said diamond-like carbon film, and the process which forms a thin film transistor on said substrate film.
[0016] Moreover, the configuration of other invention is the production approach of the semiconductor device characterized by having the process which forms a thin film transistor on an insulating substrate, the process which covers said thin film transistor and forms an interlayer insulation film, and the process which forms a diamond-like carbon film on said interlayer insulation film.
[0017]
[Embodiment of the Invention] In drawing 1 , the diamond-like carbon film (it is called the DLC film below) 102 is formed in the front face of an insulating substrate 101 (drawing 1 (A)). And TFT is formed by the well-known approach (drawing 1 (B)). Thus, the DLC film is prepared in a liquid crystal display as film for preventing an electrostatic discharge.
[0018] The specific resistance of the DLC film is smaller than the ingredient (it is a quartz, glass, etc. and specific resistance is 1016-1019-ohmcm about) used for 107-1014-ohmcm and an insulating substrate. Therefore, static electricity charged in the liquid crystal display, especially the substrate can be missed, and the electrostatic discharge of gate dielectric film 104 can be prevented.
[0019] Moreover, since the DLC film is prepared in the substrate before forming TFT, not only under use of a liquid crystal display but the electrostatic discharge which is producing [the] and happens can be prevented.
[0020] Furthermore, for the DLC film, Vickers hardness is 2 2000 to 5000 kgf/mm. Since it is hard, the role from which the front face of a substrate is protected is also played.
[0021] In addition, since the DLC film penetrates the light and infrared light, it can be applied to the transparency mold liquid crystal display which a substrate and liquid crystal are made to penetrate light and displays an image.
[0022] Below, the example of this invention is shown. In addition, although the top gate mold TFT is shown by each example, the effectiveness of this invention can be acquired also by TFT of other structures.
[0023]
[Example] [Example 1] This example explains the configuration and making process of a transparency mold liquid crystal display of this invention using drawing 1 . However, it is the sectional view of TFT of a active-matrix circuit which is shown in drawing 1 .
[0024] The DLC film 102 is formed in the front face of an insulating substrate 101 in drawing 1 (A). It is indicated by JP,3-72711,B, JP,4-27690,B, and JP,4-27691,B about the detailed membrane formation approach and membrane formation equipment.
[0025] In addition, since a transparency mold liquid crystal display is produced in this example, the DLC film must be transparent. However, although the DLC film is based also on membraneous quality, brown (or yellow) is gradually worn as thickness increases, and permeability falls. Moreover, if the DLC

film is not much thin, uniform membrane formation can also seldom expect the effectiveness of it being difficult and missing static electricity. Therefore, thickness of the DLC film is set to 5-100nm in this example.

[0026] Moreover, it is more desirable to use a quartz substrate from a glass substrate as an insulating substrate. This is based on the following reasons.

[0027] A glass substrate is heated by the elevated temperature at processes, such as crystallization of the amorphous silicon film, and membrane formation of an insulator layer, in the making process of next TFT. However, at these processes, since it heats to the temperature near the temperature (600 degrees C) of the point [distortion] of a glass substrate, a glass substrate will be contracted. Moreover, the DLC film is very hard film, as mentioned above. Therefore, in case a glass substrate contracts, the DLC film breaks or there is a possibility of exfoliating.

[0028] To it, since point [distortion] temperature is 1000 degrees C or more, contracting in a TFT making process does not almost have a quartz substrate.

[0029] Furthermore, in order to improve the adhesion of an insulating substrate 101 and the DLC film 102, it is good to prepare a buffer layer between an insulating substrate 101 and the DLC film 102. As a buffer layer, it is good to use the silicon film, the silicon carbide film, etc.

[0030] And the semi-conductor film 103 is formed in insulating-substrate top 101. What is necessary is just to use the amorphous silicon film, the polycrystal silicon film, etc. as semi-conductor film. Moreover, before forming the semi-conductor film 103, substrate film, such as oxidation silicon film and a silicon nitride film, may be formed on an insulating substrate 101.

[0031] Next, gate dielectric film 104 and the gate electrode 105 are formed on the semi-conductor film 103. Then, into the semi-conductor film, an impurity is poured in and the source field 106 and the drain field 107 are formed. A channel formation field is formed in 108.

[0032] Next, gate dielectric film 104 and the gate electrode 105 are covered, and the 1st interlayer insulation film 109 is formed. And a contact hole is formed in gate dielectric film 104 and the 1st interlayer insulation film 106, and the source electrode 107 and the drain electrode 108 are formed. In this way, TFT is formed (drawing 1 (B)).

[0033] And TFT is covered, the 2nd interlayer insulation film 109 is formed, and a light-shielding film 110 is formed on the 2nd interlayer insulation film of the TFT upper part. And the pixel electrode 112 which becomes by translucency electric conduction film, such as ITO, is formed after forming the 3rd interlayer insulation film 111 (drawing 1 (C)). In addition, what is necessary is just to use the approach that these production approaches are also well-known.

[0034] And a liquid crystal display is completed by the well-known approach.

[0035] [Example 2] This example explains the transparency mold liquid crystal display of other configurations of this invention using drawing 2 . It is the sectional view of the active-matrix circuit section which is shown in drawing 2 .

[0036] As first shown in drawing 2 (A), TFT202 is formed on an insulating substrate 201 like an example 1. 203 is the 1st interlayer insulation film. And TFT202 is covered and the 2nd interlayer insulation film 204 is formed. Next, the DLC film 205 is formed on the 2nd interlayer insulation film 204 at the thickness of 5-100nm (drawing 2 (B)).

[0037] At this time, it is good to use the organic resin film for the 2nd interlayer insulation film 204. Since both the organic resin film and the DLC film are the matter of a carbon system, this has good adhesion. Therefore, it is because the DLC film cannot separate easily from the organic resin film. Polyimide, a polyamide, polyimidoamide, an acrylic, etc. are raised as organic resin film.

[0038] And a light-shielding film 206 is formed on the DLC film 205, and the 3rd interlayer insulation film 207 is formed further. The organic resin film (it is called the black resin film below) which distributed a black pigment and graphite as a light-shielding film 206, the electric conduction film (typically metal membranes, such as titanium, chromium, and aluminum) which has protection-from-light nature can be used. It is more desirable to use the black resin film, since especially black resin has good adhesion with the DLC film.

[0039] And a contact hole is formed and the pixel electrode 208 is formed using translucency electric

conduction film, such as ITO, (drawing 2 (C)). In addition, in case a contact hole is formed, the DLC film 205 can be etched by the oxygen plasma, the hydrogen plasma, ion milling, etc.
[0040] Furthermore, a liquid crystal display is completed using a well-known approach.
[0041] Thus, even if it uses the configuration which formed the DLC film 205 above TFT202, the electrostatic discharge of TFT can be prevented.
[0042] [Example 3] In the examples 1 and 2, although the transparency mold liquid crystal display was explained, it is applicable also like a reflective mold liquid crystal display. What is necessary is just to use the electric conduction film which has the reflexibility of the ingredient which uses aluminum or aluminum as a principal component as a pixel electrode.
[0043] Moreover, since it is not necessary to take the permeability of the DLC film into consideration in the case of a reflective mold liquid crystal display, thickness can be thickened to extent in which the film does not exfoliate, and the effectiveness which misses static electricity can be heightened. actual -- 50-200nm (preferably 100-150nm) -- then, it is good.
[0044] [Example 4] Although the example 1 explained the case where the DLC film was prepared in a field opposite to the field which forms TFT of a substrate, this example explains the case where the DLC film is prepared in the field which forms TFT. It is the sectional view of the active-matrix circuit section of this example which is shown in drawing 3 .
[0045] First, the DLC film 302 is formed like an example 1 on an insulating substrate 301. The thickness of the DLC film 302 may be 5-100nm. In addition, when producing a reflective mold liquid crystal display, it may be 50-200nm (preferably 100-150nm).
[0046] In order to raise the adhesion of a substrate 301 and the DLC film 302 at this time, buffer layers, such as silicon or silicon carbide, may be prepared among them. Moreover, it is more desirable to use a quartz substrate from a glass substrate as an insulating substrate in consideration of the heat-treatment in the making process of next TFT.
[0047] Next, insulator layers, such as oxidation silicon film or a silicon nitride film, are formed as substrate film 303 on the DLC film 302. And TFT304 is formed on the substrate film 303 using a well-known approach.
[0048] Thus, even if it uses the configuration shown in this example, an electrostatic discharge production of a liquid crystal display and in use can be prevented.
[0049] [Example 5] This example explains the configuration of the liquid crystal display which has a active-matrix circuit and a drive circuit on the same substrate. The configuration of the substrate which has a active-matrix circuit and a drive circuit is shown in drawing 4 .
[0050] On the insulating substrate 401, the active-matrix circuit 402, the gate drive circuit 403, the source drive circuit 404, and the logical circuit 405 are formed. The drive circuit consists of CMOS circuits which combined the N channel mold TFT and the P channel mold TFT complementary. Moreover, a logical circuit 405 is a digital disposal circuit which processes conversion, amendment, etc. of a picture signal. An A/D converter circuit, a gamma correction circuit, and a memory circuit are contained, and, specifically, these also consist of TFT(s).
[0051] And the DLC film 406 is formed in the opposite side of the field in which the circuit of an insulating substrate 401 is formed. This DLC film 406 can protect the electrostatic discharge of not only TFT of a active-matrix circuit but TFT of the gate drive circuit 403, the source drive circuit 404, and a logical circuit 405.
[0052] In addition, the DLC film 406 may be formed above TFT like an example 2, or may be prepared between TFT and an insulating substrate like an example 4.
[0053] [Example 6] The configuration of this invention is applicable to other various electro-optic devices and semiconductor circuits besides a liquid crystal display.
[0054] EL (electroluminescence) equipment, image sensors, etc. are mentioned as electro-optic devices other than a liquid crystal display. Moreover, the high frequency modules (MMIC etc.) handling the I/O signal of a data-processing circuit like the microprocessor which consists of IC chips as a semiconductor circuit, and a pocket device etc. are mentioned.
[0055] Thus, this invention is applicable to all the semiconductor devices that function with the

semiconductor circuit which consists of TFT(s).

[0056] [Example 7] The electro-optic device and semiconductor circuit which were shown in examples 5 and 6 are used for various electronic equipment. As this electronic equipment, a video camera, a still camera, a projector, Projection TV, a head mount display, car NEBIGESHON, a personal computer, Personal Digital Assistants (a mobile computer, cellular phone, etc.), etc. are mentioned. Those examples are shown in drawing 5 .

[0057] It is the cellular phone which is shown in drawing 5 (A), and consists of a body 2001, the voice output section 2002, the voice input section 2003, an indicating equipment 2004, an actuation switch 2005, and an antenna 2006. This invention is applicable to the voice output section 2002, the voice input section 2003, and a display 2004.

[0058] It is the video camera which is shown in drawing 5 (B), and consists of a body 2101, an indicating equipment 2102, the voice input section 2103, an actuation switch 2104, a dc-battery 2105, and the television section 2106. This invention is applicable to a display 2102, the voice input section 2103, and the television section 2106.

[0059] It is the mobile computer which is shown in drawing 5 (C), and consists of a body 2201, the camera section 2202, the television section 2203, an actuation switch 2204, and a display 2205. This invention is applicable to the television section 2203 and a display 2205.

[0060] It is the head mount display which is shown in drawing 5 (D), and consists of a body 2301, an indicating equipment 2302, and the band section 2303. This invention is applicable to a display 2302.

[0061] It is the rear mold projector which is shown in drawing 5 (E), and consists of a body 2401, the light source 2402, an indicating equipment 2403, a polarization beam splitter 2404, reflectors 2405 and 2406, and a screen 2407. This invention is applicable to a display.

[0062] It is the front mold projector which is shown in drawing 5 (F), and consists of a body 2501, the light source 2502, a display 2503, optical system 2504, and a screen 2505. This invention is applicable to a display 2503.

[0063] As mentioned above, the applicability of this invention is very wide, and applying to the electronic equipment of all fields is possible.

[0064]

[Effect of the Invention] By taking the configuration of this invention, static electricity charged in the substrate can be missed and the electrostatic discharge of TFT can be prevented. And a reliable electro-optic device and a reliable semiconductor circuit, and the electronic equipment which carried them are realizable.

[Translation done.]